

REMARKS

Claims 27, 29, 32, and 34 have been amended as discussed below. No claims have been added or canceled. Accordingly, Claims 1 and 3 - 35 remain pending.

Dependent Claim 26 has been objected to under 37 CFR 1.75(c) as lacking antecedent basis for the expression "the doped silicon section". Claim 26 has also been objected to as failing to limit Claim 23 from which Claim 26 depends. These objections are respectfully traversed.

In presenting the foregoing objections to Claim 26, the Examiner may have overlooked the fact that Claim 23 was revised in the amendment submitted 15 July 2003 to delete the term "monocrystalline" before "doped silicon section". More particularly, Claim 26 is repeated below preceded by Claim 23 as amended in the 15 July 2003 amendment:

23. The method of Claim 8 wherein:

the body comprises an erasable programmable read-only memory region; and

the cobalt silicide layer is formed to contact a doped silicon section of the erasable programmable read-only memory region.

26. The method of Claim 23 wherein the doped silicon section comprises doped monocrystalline silicon.

The deletion of "monocrystalline" in Claim 23 broadened that claim. Subject to Claim 26 being open-ended as to the full constituency of the doped silicon section, the "monocrystalline" limitation of the previous version of Claim 23 was essentially transferred to Claim 26.

In any event, Claim 23 now recites "a doped silicon section". This recitation provides antecedent basis for "the doped silicon section" recited in Claim 26. With respect to the recitation in Claim 26 that the doped silicon section comprises doped "monocrystalline" silicon, doped silicon can be in monocrystalline form or in non-monocrystalline form such as polycrystalline or amorphous form. Hence, the recitation in Claim 26 that the doped silicon section comprises "monocrystalline" silicon further limits Claim 23 which introduces the

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"doped silicon section". The 37 CFR 1.75(c) objections to Claim 26 should thus be withdrawn.

Dependent Claims 29, 31, 32, 34, and 35 have been objected to under 37 CFR 1.75(c) apparently due to the use of allegedly inconsistent terminology. This objection is respectfully traversed in view of the revisions to the claims.

With respect to Claims 29 and 34, the Examiner apparently objects to the expression "the regions and gates" as not clearly (or fully) identifying the particular regions and gates. The Examiner has suggested that "the regions and gates" in each of Claims 29 and 34 be changed to "the source/drain regions and the floating and control gates".

Claim 29 depends from Claim 27 by way of Claim 28. Claim 34 depends from Claim 27 by way of Claims 32 and 33. Claims 28 and 32 each introduce a pair of source/drain regions and a body region. As a result, the term "the regions" in the phrase "the regions and gates" in each of Claims 29 and 34 means the source/drain and body regions, not just the source/drain regions. In light of this, "the regions" in the phrase "the regions and gates" of each of Claims 29 and 34 has been changed to "the source/drain and body regions".

Claim 27 introduces a "floating gate" and a "control gate". No other "gate" is introduced in any of Claims 27 - 29. The term "gates" in the phrase "the regions and gates" in Claim 29 thus means the floating and control gates. Consistent with the Examiner's suggestion, "gates" in the phrase "the regions and gates" in Claim 29 has been changed to "the floating and control gates". Also, for consistency with the revisions to Claim 29, the term "the gates" in Claim 27 has likewise been changed to "the floating and control gates".

Claim 32, which depends from Claim 27 and from which Claim 34 depends by way of Claim 33, introduces a "select gate". As a consequence, the term "gates" in the phrase "the regions and gates" in Claim 34 means the floating, control, and select gates. With this in mind, the term "gates" in the phrase "the regions and gates" in Claim 34 has been changed to "the floating, control, and select gates".

With respect to Claim 32, the Examiner apparently objects to the expression "the other gates" as not clearly identifying the particular "other gates". The Examiner has suggested that "the other gates" in Claim 32 be changed to "the floating and control gates". The Examiner's suggestion has been adopted.

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With respect to Claims 31 and 35, the Examiner apparently objects to the phrase "that other of the source/drain regions" as not clearly indicating which of the source/drain regions is "that other" source/drain region. The Examiner has suggested that "that other of the source/drain" regions be changed to "the other of the source/drain" regions. Unfortunately, Applicants' Attorney believes that modifying Claims 31 and 35 in the manner suggested by the Examiner would make the two claims unclear rather than clear.

More particularly, let the two source/drain regions be referred to as source/drain regions A and B. Claim 31 depends from Claim 30 which recites that the floating gate extends partially over "one of the source/drain regions", e.g., source/drain region A. Based on the foregoing recitation in Claim 30, Claim 31 recites that a further cobalt layer is formed over "the other of the source/drain regions", i.e., source/drain region B in the present example.

Claim 31 later recites that cobalt of the further cobalt layer is reacted with silicon of "that other of the source/drain regions" to form a further cobalt silicide layer. Inasmuch as Claim 31 earlier recites that the further cobalt layer is formed over "the other of the source/drain regions", "that other of the source/drain regions" is "the other of the source/drain regions" recited earlier in Claim 31 and is thus source/drain region B in the present example.

If, however, "that other of the source/drain" regions in Claim 31 were changed to "the other of the source/drain" regions per the Examiner's suggestion, the resultant second recitation of "the other of the source/drain regions" in Claim 31 might be interpreted to mean the source/drain region other than "the other of the source/drain regions" recited earlier in Claim 31. That is, the second recitation of "the other of the source/drain regions" in Claim 31 might be interpreted to mean source/drain region A rather than intended source/drain region B in the present example. Adopting the Examiner's suggestion could thus lead to Claim 31 not covering the intended subject matter and thus essentially being wrong.

Similar comments apply to Claim 35. Claim 33, from which Claim 35 depends, recites that the floating gate extends partially over "one of the source/drain regions", e.g., again source/drain region A. Analogous to Claim 31 and based on the foregoing recitation in Claim 33, Claim 35 recites that a further cobalt layer is formed over "the other of the source/drain regions", i.e., source/drain region B in the present example.

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Claim 35 later recites that the further cobalt layer is reacted with silicon of "that other of the source/drain regions", i.e., again source/drain region B in the instant example. For the reasons presented above in connection with Claim 31, changing "that other of the source/drain regions" in Claim 35 to "the other of the source/drain regions" might lead to the resultant second recitation of "the other of the source/drain regions" being interpreted to mean source/drain region A and thus the wrong source/drain region. As with Claim 31, Claim 35 would essentially be wrong.

For the preceding reasons, Applicants' Attorney believes that it is inappropriate to adopt the Examiner's suggestion with respect to amending Claims 31 and 35. These two claims accurately describe the intended subject matter as they are now worded. The 37 CFR 1.75(c) objection to Claims 31 and 35 should be withdrawn.

Claim 32 has been rejected under 35 USC 112 as indefinite for failing to particularly point out and distinctly claim the invention. This rejection is respectfully traversed.

With emphasis on "generally", the Examiner alleges that the expression "generally lateral to" in Claim 32 is a relative term that makes Claim 32 indefinite. The Examiner specifically alleges that "The aforementioned term is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably appraised [sic, apprised] of the scope of the invention".

Relative terms such as "substantially", "approximately", "generally", and the like are acceptable in U.S. patent claims. It has been recognized for many years that the scope of such a relative term can be determined by a person skilled in the art in light of what is described in the specification. This applies to the use of "generally" in Claim 32. The 35 USC 112 indefiniteness rejection of Claim 32 should therefore be withdrawn.

Claims 1, 4, 6 - 8, 11, 12, and 14 - 20 have been rejected under 35 USC 103(a) as obvious based on Hu, U.S. Patent 6,392,302 B1, in view of Lee, U.S. Patent Publication 2002/0001946 A1. This rejection is respectfully traversed.

Hu discloses a semiconductor fabrication technique in which cobalt layer 26 is deposited by physical vapor deposition, preferably sputtering, over upper polycrystalline silicon ("polysilicon") layer 18 of a gate stack suitable for use in an integrated circuit such as dynamic random-access memory ("DRAM"). Titanium layer 28 is deposited on cobalt

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layer 26. An anneal is performed to create cobalt silicide layer 30 from cobalt in cobalt layer 26 and silicon in upper polysilicon layer 18. The titanium and any unreacted cobalt are subsequently removed.

Lee discloses a semiconductor fabrication technique in which titanium film 22 is deposited on semiconductor substrate 21 by ionized physical vapor deposition ("IPVD"), titanium nitride film 23 is formed on titanium film 22, and aluminum film 24 is formed on titanium nitride film 23. Aluminum film 24 functions as the primary interconnect metal for the metalization interconnect system. The use of IPVD to create titanium film 22 causes it to have an improved <002> crystal orientation. This causes titanium nitride film 23 to have an improved <111> crystal orientation. The improved <111> crystal orientation of nitride film 23, in turn, causes aluminum film 24 to have an improved <111> crystal orientation and, as a result, improved electromigration resistance. Forming titanium film 22 by IPVD thus improves the electromigration resistance of aluminum film 24.

Independent Claims 1 and 8 are repeated below:

1. A method for forming cobalt suicide on a body which has a surface that comprises silicon, the method comprising:

forming a cobalt layer on said surface;

forming a titanium layer over the cobalt layer by ionized physical vapor deposition while the body is attached to a support biased with an AC power of 0 W;

reacting the cobalt with the silicon to form cobalt suicide; and

removing the titanium layer, and if any cobalt has not reacted with the silicon then removing the unreacted cobalt.

8. A method comprising:

forming a cobalt layer over a body that comprises silicon;

forming a titanium layer over the cobalt layer by ionized physical vapor deposition;

reacting cobalt of the cobalt layer with silicon of the body to form a cobalt silicide layer; and

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substantially removing the titanium layer and any unreacted cobalt of the cobalt layer.

Claims 1 and 8 each require that the titanium layer in the cobalt-based interconnect be formed by IPVD.

With respect to Claims 1, 4, 7, 8, and 15, the Examiner alleges on pages 3 and 4 of the Office Action that "Hu teaches the claimed method" but "is silent as to the titanium layer 28 being formed by a physical vapor deposition (PVD)". After stating that "Lee, however, in an analogous art teach utilizing IPVD for forming the titanium layer would provide an excellent orientation and thus improve the reliability of the resulting metal interconnect, in which the AC bias is in a range of 0 to 500 W (paragraphs [0020],[0023], [0026])", the Examiner alleges that "Therefore, one of the ordinary skill in the art, at the time the invention was made, would have been motivated to utilize the IPVD method as suggested by Lee for forming the PVD-deposited titanium layer of Hu, since by doing so it would improve the reliability of the resulting metal structure".

Titanium layer 28 in Hu protects cobalt layer 26 during the formation of cobalt silicide layer 30 and is removed directly after the formation of silicide layer 30. Inasmuch as titanium layer 28 is removed after silicide layer 28 is formed, forming titanium layer 28 by IPVD would not improve the electromigration resistance of any later-formed layer such as a later-formed aluminum layer. Since Lee forms its titanium film 22 by IPVD to improve the electromigration resistance of later-formed aluminum film 24 and since the formation of Hu's titanium layer 28 by IPVD in the manner proposed by the Examiner would not improve the electromigration resistance of anything, nothing in Lee would provide a person skilled in the art with any motivation or incentive to form Hu's titanium layer 28 by IPVD. Claims 1 and 8 are thus patentable over Hu and Lee.

Claims 4, 6, and 7 all depend (directly or indirectly) from Claim 1. Claims 11, 12, and 14 - 20 all depend (directly or indirectly) from Claim 8. Hence, dependent Claims 4, 6, 7, 11, 12, and 14 - 20 are patentable over Hu and Lee for the same reasons as Claims 1 and 8.

Furthermore, neither Hu nor Lee discloses the further limitation of Claim 11 that the acts of forming the cobalt and titanium layers be performed in a chamber at below atmospheric pressure without exposing the body to atmospheric pressure (during the period) between the two forming acts. Claim 11 is thus separately allowable over Hu and Lee.

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Claims 3, 5, 13, 21, and 22 have been rejected under 35 USC 103(a) as obvious based on Hu and Lee taken with D'Couto et al. ("D'Couto"), U.S. Patent 6,342,133 B2. This rejection is respectfully traversed.

D'Couto discloses a semiconductor fabrication technique in which a titanium layer is deposited by sputtering titanium atoms and ions into an opening in a body. In one embodiment, the titanium layer extends out of the opening and is covered in sequence by a titanium nitride layer, an aluminum layer, and another titanium layer. In another embodiment, the titanium layer is situated only at the bottom of the opening and is covered in sequence by a titanium nitride layer and a tungsten region that fills the remainder of the opening.

Claims 3 and 5 both depend from Claim 1. Claims 13, 21, and 22 all depend (directly or indirectly) from Claim 8.

Nothing in D'Couto would provide a person skilled in the art with any motivation or incentive for combining Hu and Lee to achieve the subject matter of Claim 1 or 8. Nor would anything in D'Couto provide a person skilled in the art with any suggestion for utilizing ion sputtering to create Hu's titanium layer 28. Dependent Claims 3, 5, 13, 21, and 22 are thus patentable over Hu, Lee, and D'Couto for the same reasons that Claims 1 and 8 are patentable over Hu and Lee.

Claims 9 and 10 have been rejected under 35 USC 103(a) as obvious based on Hu and Lee taken with Liu et al. ("Liu"), U.S. Patent 6,329,277 B1. This rejection is respectfully traversed.

Liu discloses a semiconductor fabrication technique in which a layer of reducing material is deposited on a native layer of silicon oxide situated along a silicon-containing body. The reducing material consists of one or more of tantalum, magnesium, aluminum, and calcium. A cobalt layer is deposited on the reducing material layer. An anneal is performed (a) to react cobalt of the cobalt layer with silicon of the body to form a cobalt silicide layer and (b) to cause the reducing material to reduce the native oxide layer. Liu reports that the reducing material, including the reduced oxygen, diffuses through the cobalt layer to its upper surface during the anneal. The reducing material is then removed along with any unreacted cobalt.

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Claims 9 and 10 both depend (directly or indirectly) from Claim 8. Nothing in Liu would provide a person skilled in the art with any suggestion or incentive for combining Hu and Lee to attain the subject matter of Claim 8. Accordingly, dependent Claims 9 and 10 are patentable over Hu, Lee, and Liu for the same reasons that Claim 8 is patentable over Hu and Lee.

Claims 23 - 27 have been rejected under 35 USC 103(a) as obvious based on Hu and Lee taken with "applicants' admitted prior art", presumably the material disclosed in the Background section of the present application at pages 1 and 2, and Horiguchi et al. ("Horiguchi"), U.S. Patent Publication 2001/0002712 A1. This rejection is respectfully traversed.

The starting point for the Background material disclosed on pages 1 and 2 of the specification is an insulated-gate field-effect transistor ("FET") having a single doped polysilicon gate electrode and a pair of doped monocrystalline silicon ("monosilicon") source/drain regions. A cobalt layer is sputter deposited on top of the structure. A titanium layer is sputter deposited on the cobalt layer. An anneal is performed to create a cobalt silicide layer from cobalt in the cobalt layer and silicon in the gate electrode and the source/drain regions. The titanium layer and any unreacted cobalt are subsequently removed.

Horiguchi discloses a non-volatile semiconductor memory¹ whose memory elements consist of floating-gate FETs, each having floating gate 5 and one or both of upper control gate 7 and side control gate 11. When control gates 7 and 11 are both present in each memory element, they can be connected together by electrically conductive cobalt silicide

¹ On page 9 of the Office Action, the Examiner alleges that a conventional "DRAM" would comprise a floating gate and a control gate as "evidenced" by Horiguchi. Applicants' Attorney believes, however, that the Examiner has misread Horiguchi.

A floating-gate FET is utilized as a memory element in a non-volatile semiconductor memory, such as an erasable programmable read-only memory ("EPROM"), which retains the stored information when the memory's power is removed. A DRAM is a volatile semiconductor memory whose stored information is lost (evaporates) when the memory's power is removed. Although a DRAM section is combined with an EPROM section in some semiconductor memories, a DRAM itself does not normally utilize floating-gate FETs in its memory elements.

The background section of Horiguchi mentions DRAMs in one paragraph and, in a later paragraph, mentions flash memories that utilize floating-gate FETs. A flash memory is a type of EPROM. However, nowhere does Horiguchi state that a floating-gate FET is employed in a DRAM. Likewise, Horiguchi nowhere discloses any of its inventive semiconductor memories as being a DRAM.

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film 27. In that case, electrically conductive cobalt silicide films 25 and 26 are provided along the source/drain regions of the floating-gate FET in each memory element. With control gates 7 and 11 consisting of doped polysilicon and with the source/drain regions consisting of doped monosilicon, cobalt silicide layers 25 - 27 are created by depositing cobalt on the upper surface of the partially fabricated memory, performing a heat treatment to react part of the cobalt with underlying silicon, and removing unreacted cobalt.

Claims 23 - 27 all depend (directly or indirectly) from Claim 8. Neither Horiguchi nor the material described in the Background section of the present application would provide a person skilled in the art with any incentive or motivation for combining Hu and Lee to achieve the subject matter of Claim 8. Consequently, Claims 23 - 27 are patentable over Hu, Lee, Horiguchi, and the application's Background material for the same reasons that Claim 8 is patentable over Hu and Lee.

Furthermore, Claims 23 and 24 each recite that the body includes an electrically erasable read-only memory ("EPROM") region. As is well known, EPROMs employ variable-threshold FETs, typically floating-gate devices. Nowhere does the Background section of the present application disclose a variable-threshold FET such as a floating-gate device. Consequently, the application's Background section does not disclose, or deal with, an EPROM region as specified in Claims 23 and 24.

Even if there were some rationale by which the Background material of the present application could be applied to Hu and Lee for making Claim 8 obvious, the combination of Hu, Lee, and the material in the application's Background section would not teach the full subject matter of Claim 23 or 24. While Horiguchi does teach floating-gate FETs, Horiguchi does not disclose the use of titanium in forming cobalt silicide films 25 - 27. Hence, there would be no reason for applying Horiguchi to the attempted combination of Hu, Lee, and the Background material of the present application. For this reason, Claims 23 and 24 are separately allowable over Hu, Lee, Horiguchi, and the application's Background material. The same applies to Claims 25 and 26 since they respectively depend from Claims 24 and 23.

Claim 27 recites particular details of a floating-gate FET. The comments made above about Horiguchi and the Background material of the present application in regard to Claims 23 and 24 carry over to Claim 27. For this reason, Claim 27 is separately allowable over Hu, Lee, Horiguchi, and the application's Background material.

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Claims 28 - 31 and 33 - 35 have been indicated as being allowable if rewritten in independent form. Claims 28 - 31 all depend from Claim 27. Inasmuch as Claim 27 has been shown to be allowable over the applied art, Claims 28 - 31 are allowable in their present form.

Claims 33 - 35 all depend (directly or indirectly) from Claim 32 which depends from Claim 27. Claim 32 has been rejected under 35 USC 112 but not on any prior art grounds. Since the 35 USC 112 rejection of Claim 32 has been shown to be inappropriate and since Claim 27 has been shown to be allowable over the applied art, Claims 33 - 35 are allowable in their present form. The same applies to Claim 32.

In summary, the 35 USC 112 indefiniteness rejection of Claim 32 should be withdrawn. Claims 1 and 3 - 27 have been shown to be patentable over the applied art. Claims 28 - 31 and 33 - 35, along with Claim 32, are allowable in their current form. Accordingly, Claims 1 and 3 - 35 should be allowed so that that application may proceed to issue.

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